MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023

ETM2046 – ANALOG AND DIGITAL COMMUNICATIONS

(RE)

08 JULY 2023
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 8 pages including cover page and appendices with 4 questions only.

2. Attempt ALL 4 questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the answer booklet provided

QUESTION 1

a) The complex exponential Fourier series of a function $x(t)$ is given as

$$x(t) = \sum_{n=-\infty, n\neq 0}^{\infty} \frac{2j}{n}\cos(n\pi)e^{jnt}$$

i) Given D_0=0, find the values of D_n for $-3 \leq n \leq 3$.

(Hint: $x(t) = \sum_{n=-\infty}^{\infty} D_n e^{jn\omega t}$)

[8 marks]

ii) Based on your answer in part (i), plot the exponential **Fourier spectra** (magnitude spectrum and phase spectrum).

[4+4 marks]

b) Given $x(t) = rect\left(\frac{t}{4}\right)$, find the Fourier Transform of:

i) $3x(t) + x(2t)$

ii) $x(t)e^{j6\pi t}$

iii) $\frac{d^2x(t)}{dt^2}$

[3+3+3 marks]

Continued ....

QUESTION 2

a) An audio signal with amplitude of 3V and frequency 8kHz modulates a carrier signal with amplitude of 5V and frequency 1MHz.

(i) Write the mathematical expression for the Double Sideband Suppressed Carrier (DSB-SC) modulated signal, and sketch the single-sided frequency spectrum

[3+3 marks]

(ii) Write the mathematical expression for the Single Sideband (SSB) modulated signal, given the lower sideband is transmitted.

[2 marks]

(iii) Write the mathematical expression for the Single Sideband (SSB) modulated signal, given the upper sideband is transmitted.

[2 marks]

b) With the aid of block diagram, show the design of an Armstrong indirect FM modulator to generate an FM carrier with a carrier frequency of 98.8 MHz and Δf=50kHz. A narrowband FM generator is available at a carrier frequency of 125 kHz and a frequency deviation Δf=10Hz. You are given an oscillator with an adjustable frequency in the range of 10 to 11MHz, plenty of frequency doublers (x2) triplers (x3) and quintuplers (x5).

[15 marks]

Continued .....

QUESTION 3

(a) Given a PCM binary data 10101101. Sketch the corresponding signalling line code waveforms of the PCM binary data using:

i) Unipolar NRZ

ii) Polar NRZ

iii) Unipolar RZ

iv) Manchester

[8 marks]

(b) Given an audio system with sampling frequency of 44.1 kHz and 16 bits quantization, determine the following:

(i) The maximum audio frequency

[2 marks]

(ii) Number of discrete levels it can produce

[2 marks]

(iii) The bit rate

[2 marks]

(iv) Is it possible to stream this audio over 512 kbps bandwidth internet? Explain

[2 marks]

(c) A 9,600 bits/s data terminal is connected to a modem. What is the transmission bandwidth, B_T, required at the modem output for each of the following schemes? 50% roll-off shaping is used in all cases.

(i) Binary ASK.

[3 marks]

(ii) Binary FSK. Assuming that the frequency deviates ±3,600 Hz about the carrier.

[3 marks]

(iii) 16-state QAM.

[3 marks]

Continued .....

QUESTION 4

(a) A discrete memoryless source has an alphabet of five symbols whose probabilities of occurrence are as described below.

$$P(S0)=0.45,\quad P(S1)=0.22,\quad P(S2)=0.14,\quad P(S3)=0.10,\quad P(S4)=0.09$$

i) Construct the Huffman code for this source.

[9 marks]

ii) Compute the average codeword length, L.

[3 marks]

iii) Calculate the entropy of the source, H.

[3 marks]

(b) The generator polynomial of a (7,4) cyclic code is $g(D) = 1 + D^2 + D^3$. Find the codeword for the message, $m(D) = D+D^2$, using polynomial division.

[10 marks]

Continued .....

Appendix I: Table of Bessel Function

n \ β	0.05	0.1	0.2	0.3	0.5	0.7	1.0	2.0	3.0	5.0	7.0	8.0	10.0
0	0.999	0.998	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0178	0.300	0.172	-0.246
1	0.025	0.050	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328	-0.005	0.235	0.043
2		0.001	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047	-0.301	-0.113	0.255
3				0.001	0.003	0.007	0.020	0.129	0.309	0.365	-0.168	-0.291	0.058
4						0.001	0.002	0.034	0.132	0.391	0.158	-0.105	-0.220
5								0.007	0.043	0.261	0.348	0.186	-0.234
6								0.001	0.011	0.131	0.339	0.338	-0.014
7									0.003	0.053	0.234	0.321	0.217
8										0.018	0.128	0.223	0.318
9										0.006	0.059	0.126	0.292
10										0.001	0.024	0.061	0.208
11											0.008	0.026	0.123
12											0.003	0.010	0.063
13											0.001	0.003	0.029
14												0.001	0.012
15													0.005
16													0.002
17													0.001

Appendix II: Table of Trigonometric Identities

$$\sin A \sin B = \frac{1}{2}\left[\cos(A-B) - \cos(A+B)\right]$$

$$\cos A \cos B = \frac{1}{2}\left[\cos(A+B) + \cos(A-B)\right]$$

$$\sin(A+B) = \sin A \cos B + \cos A \sin B$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

$$\sin\theta = \frac{1}{2j}\left[e^{j\theta} - e^{-j\theta}\right]$$

$$\cos\theta = \frac{1}{2}\left[e^{j\theta} + e^{-j\theta}\right]$$

Continued...

Appendix III: Fourier Transform Pairs

$x(t)$	$X(f)$
$\delta(t)$	1
$\delta(t-t_o)$	$e^{-j2\pi ft_o}$
1	$\delta(f)$
$e^{j2\pi f_o t}$	$\delta(f-f_o)$
$e^{-at}u(t)$	$\frac{1}{a+j2\pi f}$, for $a>0$
$e^{at}u(-t)$	$\frac{1}{a-j2\pi f}$, for $a>0$
$e^{-a\lvert t\rvert}$	$\frac{2a}{a^2+(2\pi f)^2}$, for $a>0$
$rect\left(\frac{t}{T}\right)$	$T\text{sinc}(fT)$
$\text{sinc}(2Wt)$	$\frac{1}{2W}rect\left(\frac{f}{2W}\right)$
$\Delta\left(\frac{t}{T}\right)$	$\frac{T}{2}\text{sinc}^2\left(\frac{fT}{2}\right)$
$W\text{sinc}^2(Wt)$	$\Delta\left(\frac{f}{2W}\right)$
$e^{-\pi t^2}$	$e^{-\pi f^2}$
$\cos(2\pi f_o t)$	$\frac{1}{2}\delta(f-f_o)+\frac{1}{2}\delta(f+f_o)$
$\sin(2\pi f_o t)$	$\frac{1}{2j}[\delta(f-f_o)-\delta(f+f_o)]$

Continued...

Appendix IV: Fourier Transform Properties

Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.	
Linearity	$ax_1(t)+bx_2(t) \Leftrightarrow aX_1(f)+bX_2(f)$
Scaling ($a \neq 0$)	$x(at) \Leftrightarrow \frac{1}{\lvert a \rvert} X\left(\frac{f}{a}\right)$
Time Shifting	$x(t-t_o) \Leftrightarrow X(f)e^{-j2\pi f t_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t} \Leftrightarrow X(f-f_o)$
Time Convolution	$x_1(t) * x_2(t) \Leftrightarrow X_1(f)X_2(f)$
Frequency Convolution	$x_1(t)x_2(t) \Leftrightarrow X_1(f) * X_2(f)$
Time Differentiation	$\frac{d^n}{dt^n}x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n}X(f)$
Time Integration	$\int_{-\infty}^{t} x(\tilde{t})d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f}+\frac{1}{2}X(0)\delta(f)$
Frequency Integration	$x(t)u(t) \Leftrightarrow \int_{-\infty}^{f} X(\tilde{f})d\tilde{f}$

End of Paper